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14. ABSTRACT

The specific aim is to determine the mechanisms of nearshore sediment transport to develop models that predict the evolution of sand bar-scale morphology in response to forcing by waves and currents.

Early results from this study linked onshore sand bar motion to fluid accelerations associated with the orbital velocities of pitched-forward nonlinear shallow water waves. Field observations from the US Army Corps of Engineers Field Research Facility (FRF), Duck, NC, are consistent with net onshore sediment transport and sand bar migration caused by cross-shore gradients in asymmetrical fluid accelerations.

Based on these findings, an acceleration-based transport term has been incorporated into an energetics-based sediment transport model. Tests show that including fluid accelerations results in significantly improved model skill. In particular, the onshore migration of a sand bar observed at the US Army Corps of Engineers Field Research Facility is predicted accurately by the model.

15. SUBJECT TERMS

nearshore sediment transport, surfzone, sand bars

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Final Progress Report for "Onshore Sandbar Migration,"
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Statement of Problem Studied:

Surfzone sand bars protect beaches from wave attack, guide and constrain nearshore currents, and are a primary mechanism of cross-shore sediment transport and beach erosion and accretion. During storms, intense wave breaking on the bar crest drives strong offshore-directed currents that carry sediment seaward, resulting in offshore sandbar migration. If the beach morphology is in equilibrium, the rapid offshore bar migration observed during storms is balanced by slower onshore sediment transport and bar migration between storms. However, the causes of shoreward bar migration are unknown, and thus models for long-term beach evolution are not accurate. The problem addressed in this study is to determine the mechanisms for onshore sediment transport and sandbar migration, and to include these mechanisms in models for nearshore morphological evolution.

Summary of the most important results:

The most important result of this study was the development of a sediment transport and morphological change model that predicts the onshore bar migration observed on an ocean beach (Figure 1). In the model sediment is transported shoreward by skewed velocity accelerations. As the bar migrates shoreward, so does the location of maximum acceleration skewness, resulting in feedback between waves and morphology that drives the bar shoreward until conditions change (Figure 2). Including the effects of fluid accelerations in a commonly used transport model results in improved predictions of beach profile evolution observed over a 45-day period that included several storms separated by low-energy conditions (Figures 3 and 4). These results suggest that fluid accelerations are important to sediment transport, contributing significantly to the evolution of ocean beaches.

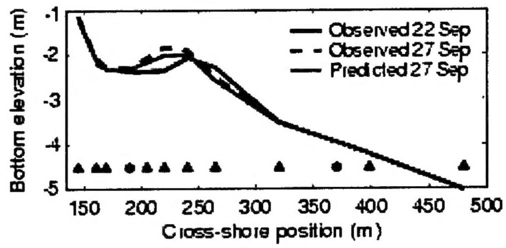

Figure 1: Observed and predicted cross-shore bottom elevation profiles. Elevation of the seafloor relative to mean sea level observed 22 Sep 1994 1900 hrs EST (black solid curve), observed 27 Sep 1994 1900 hrs (black dashed curve), and predicted by the acceleration-based transport model (red curve) versus cross-shore position. The energetics transport model (using parameters determined previously) without acceleration predicts no change in the seafloor (not shown). Cross-shore locations of colocated pressure sensors, current meters, and altimeters are indicated with triangles, and of colocated pressure sensors and current meters with circles. Observed near-bottom velocities (sampled at 2 Hz) were low-pass filtered (cutoff frequency = 0.5 Hz) and differentiated in time to obtain near-bottom acceleration time series. Sediment transport fluxes for the model predictions were computed from 3-hr averages of observed near-bottom velocity and acceleration statistics, and integrated in time with a 3-hr time step to compute predicted bottom elevation changes. Mean sediment grain sizes ranged from 0.30 mm at the shoreline to 0.15 mm in 5-m water depth.

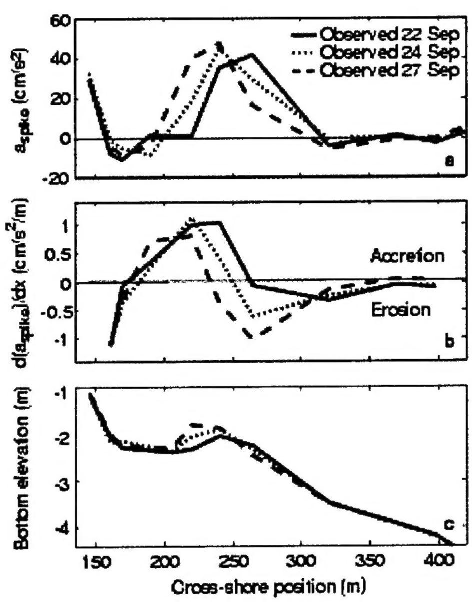

Figure 2: Acceleration skewness and bottom elevation profiles during an onshore sandbar migration event. (a) Observed acceleration skewness, (b) cross-shore gradient of acceleration skewness, and (c) seafloor elevation relative to mean sea level versus cross-shore position. The solid curves are observations from 22 Sep 1900-2200 hrs, dotted curves are 24 Sep 1300-1600 hrs, and dashed curves are 27 Sep 1900-2200 hrs.

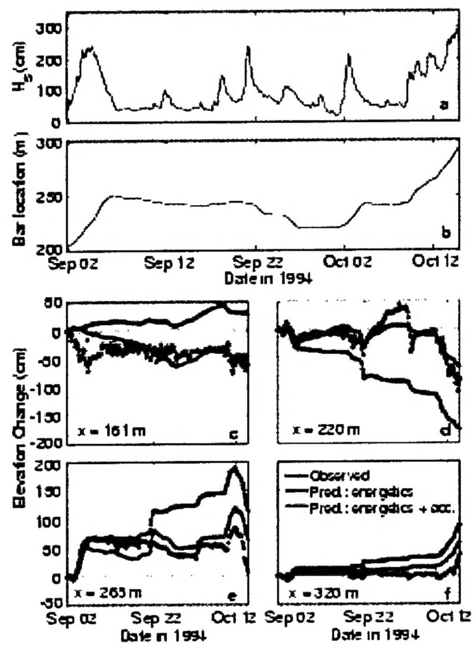

Figure 3: Observed wave height, cross-shore sandbar crest position, and observed and predicted bottom elevation changes at four cross-shore locations between 01 Sep 1900 hrs and 15 Oct 2200 hrs. (a) Significant wave height (4 times the standard deviation of 3-hr long records of sea-surface elevation fluctuations in the frequency bands between 0.01 and 0.3 Hz) observed in 5-m water depth and (b) cross-shore position of the sandbar crest versus time. The bar crest position was estimated from spatially dense surveys conducted with an amphibious vehicle approximately bi-weekly, combined with 3-hourly estimates of seafloor elevation from altimeter measurements (Figure 1). The shoreline fluctuated (owing to a 1 m tide range) about cross-shore location x=125 m. Observed (black circles) and predicted (blue curve for energetics model, red curve for combined energetics plus acceleration model) cumulative change in seafloor elevation at cross-shore locations (c) x=161, (d) x=220, (e) x=265, and (f) x=320 m. Parameters in the energetics models are the same as those used previously.

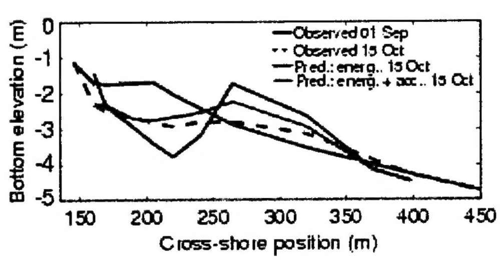

Figure 4: Observed and predicted cross-shore bottom elevation profiles spanning a 45-day period. Seafloor elevation relative to mean sea level observed 01 Sep 1900 hrs (solid black curve), observed 15 Oct 2200 hrs (dashed black curve), and predicted for 22 Oct 2200 hrs by the energetics (blue) and energetics plus acceleration (red) models versus cross-shore position.

Publications:

(a) Published in peer-reviewed journals:

Elgar, Steve, Edith Gallagher, and R.T. Guza, 2001 Nearshore sand bar migration, *J. Geophysical Research*, **106**, 11,623--11,627.

Elgar, Steve, 2001 Coastal profile evolution at Duck, North Carolina: A cautionary note, *J. Geophysical Research*, **106**, 4625--4627.

Elgar, Steve, B. Raubenheimer, T.H.C. Herbers, 2002 Bragg reflection of ocean waves from sandbars, *Geophysical Research Letters*, in press.

(b) Published in non-peer-reviewed journals or conference proceedings: none

(c) Presented at meetings

Elgar, Steve, E. Gallagher, and R.T. Guza, Onshore Sandbar Migration, Eos Trans. AGU **80**, 538, 1999.

Hoefel, Fernanda and Steve Elgar, Wave Acceleration Induced Sediment Transport in the Surf Zone, Eos Trans. AGU **83**, Abstract OS52E-04, 2002.

Elgar, Steve, B. Raubenheimer, T.H. Herbers, Bragg Reflection of Ocean Waves from Sandbars, Eos Trans. AGU **83**, Abstract OS51D-11, INVITED, 2002.

(d) Manuscripts submitted, but not published

Hoefel, Fernanda and Steve Elgar, Surfzone sandbar migration and wave acceleration induced sediment transport, *Science*, submitted 12 Dec 2002, passed initial editorial board review 19 Dec 2002.

(e) Technical reports submitted to ARO

none besides interim progress reports

Participating Scientific Personnel

WHOI-MIT Joint Program PhD student Ms. Fernanda Hoefel is working on this project for her thesis. Ms. Hoefel's stipend and tuition is supported by a fellowship, whereas her research expenses are supported by this project.

Report of inventions:

none